



Pre-During-Post Lockdown Air Quality in Adyar, Chennai, India Amid COVID-19 Pandemic

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Abstract. *The COVID-19 pandemic has shoved most of the countries to implement restrictions for transportation and all other social activities to minimize spread of disease to the people. India is the second most populated country in the world which has implemented a historical complete lockdown throughout the country from the last week of March to April 2020 with an extension up to the first week of May 2020. This lockdown has slowed down the pollution levels in most of the cities in India within the first few weeks of the lockdown. In this view, the present study discusses the air quality scenario of Chennai, one of the megacities of India, scientifically. With the aid of air quality data of the Tamil Nadu Pollution Control Board, India, for five parameters such as PM 2.5 and P.M 10, sulphur dioxide, nitrogen dioxide and air quality index, the authors correlated the pre-during-post lockdown air quality of Adyar, Chennai. The results indicated that the concentrations of particulate matter reduced to about 50 – 80 % during the lockdown compared to pre-lockdown. The concentrations of sulphur dioxide and nitrogen dioxide were decreased to 50% and 20%, respectively, within the first week of lockdown. Further the data were compared with the pollution data for the past two years (2018 and 2019). The present study gives insight on the reduction of pollution in proportion to the temporary control of pollution source at particular interval could rejuvenate the environment.*

Keywords: *air pollution, COVID 19, megacities, Chennai, India*

1. Introduction

Cities generate wealth, create jobs and accelerate human development by leveraging the process of agglomeration and urbanization. Cities with a population of more than 10 million are called megacities. India is the world's most populous, tropical and peninsular country. As of January 2021, India has five megacities namely, New Delhi, Mumbai, Kolkata, Bengaluru, and Chennai. Chennai is the capital of the state of Tamil Nadu and it is the fifth-largest city in India, which is located at 13.0827°N, 80.2707°E on the southern seashore of the Bay of Bengal. Chennai city has an area of about 426 square kilometers with a population of about 10.435 million in 2019 [1]. The population is increasing at the rate of 2.43% from 2019 and the current population is about 10.9 million people. Chennai is the home for cinema, automobile, education, IT hub and industrial sectors. Apart from the urbanization and economic development, air pollution of the city has magnified in recent decades.

The rapid industrialization and unparallel growth in population have made the city face the consequences of air pollution. Chennai belongs to the most air polluted city in India on emission and energy consumption [2]. Air pollution is complex and cocktail of physical and biological components. Several health problems such as respiratory diseases, infertility, miscarriage and birth defects are associated with air pollution [3]. Air pollution is mainly due to anthropogenic activities and the principal constituents are SO₂ NO₂ CO, PM₁₀ and PM_{2.5}. PM_{2.5} is a mixture of hydrocarbons and other compounds that are emitted from the smoke of vehicles, cooking, industry and other natural components of dust [4].

Most of the health issues related to lungs and respiration are due to PM_{2.5} [1].

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PM_{2.5} is more harmful than PM₁₀. Preceding research done by ref [4] on the vertical transport of PM_{2.5} and PM₁₀ for the Chennai city has evidenced that the concentrations of PM_{2.5} were found to be higher than the National Ambient Air Quality Standards (NAAQS). The finer PM concentrations were higher in indoor air and it is mainly due to the emission from vehicular traffic [5]. It should be noted that the residents near the industrial zone at Chennai are exposed more to PM₁₀ concentrations because the outdoor air quality is poor in industrial zones [6].

Sulphur dioxide is a gaseous pollutant and can cause respiratory and lung problems. The acidification of water bodies and soils may occur when Sulphur combines with water present in the air [7]. High temperature industrial process and burning of fuels, which contains sulphur was the major source of this pollutant to be released into the air. Nitrogen dioxide is emitted from vehicles and a high concentration of these pollutants can lead to inflammation of the lungs and prevents its functioning [8].

The effects of air pollution at Chennai have caused respiratory diseases and eye illness to the residents and PM_{2.5} concentrations were more during summer and these concentrations were higher in industrial areas than residential areas [9]. The air pollution was higher in the premonsoon season due to the influence of sea breeze and circulation of local air particularly in Chennai coastal regions [5]. Coastal meteorology influences air pollutant transport in Chennai [10]. Manali region in Chennai has a high concentration of ammonia in outdoor air and ammonia was released due to the presence of fertilizer industries [8].

Novel Corona Virus (COVID- 19) a pandemic disease was first identified in China in Wuhan in December 2019. Globally over 1605091 people have died and 70829855 have been identified as infected by COVID-19 [11]. Due to an increase in COVID- 19 cases around the world, few countries have imposed complete lockdown. On 22nd March a Nationwide lockdown was announced and Lockdown was imposed in India from 24th March 2020. Due to lock down all the public transports, shopping malls, industries were closed and strict self-quarantine measures were adopted. It was evidenced that after four days of lockdown the air pollution in 88 cities has reduced and the quality of air is improved [2]. The nationwide lockdown has provided an opportunity to find alternative control measures for improving air quality. The objectives of the present study were to compare the pollutants concentrations in air at Adyar, Chennai during the pre-lock down, complete lock down and post-lockdown period. To provide insight and scientific perception to the policymakers and the researchers, the concentration levels of major pollutants from 2018 to 2020 were also used to assess the air quality in Chennai.

2. Materials and methods

To assess the air quality, the concentrations of various air pollutants in Chennai especially in Adyar region during the lockdown period the air quality data from CPCB were used. Particularly the 24 hours average concentrations of Particulate matter (PM_{2.5} and PM₁₀), Sulphur Dioxide, Nitrogen Dioxide and AQI have been obtained from the Tamil Nadu Pollution Control Board. Data used for analysis was from January 2020 to September 2020 and the monthly intermittent day-wise data including pre-lockdown, complete lockdown and post-lock down period. Yearwise data from 2018 to 2020 were also used for comparison of the yearly concentration level of pollutants in the Adyar region.

3. Results and discussions

3.1. Change in concentration of Particulate matter

The Concentrations of particulate matter PM₁₀ and PM_{2.5} during January 2020 were 45 µg/m³ and 28 µg/m³, respectively (Figure 1 and Table 1). The peak concentration of PM₁₀ was 58 µg/m³ and it was observed in March 2020 and it has declined during the end of March 2020. According to NAAQS 2009 the peak concentration limit for the particulate matter PM₁₀ is 100 µg/m³ and for PM_{2.5} is 60 µg/m³ but both the parameter's concentration levels were within the acceptable limit. On contrary the peak concentration of PM_{2.5} was 32 µg/m³ during the pre-lockdown period, at the end of the pre-lockdown the concentrations decreased to 25 µg/m³.



On average there was a decrease of 50% in the concentrations of particulate matter, PM₁₀ and PM_{2.5} have decreased drastically about 80% during the complete lockdown period when compared to peak concentration at the pre-lockdown period and these shows the effects of lockdown in improving the air quality. However, there was a partial relaxation after two weeks for commodity transport and also controlled industrial operation outside the COVID-19 infected areas and the particulate matter PM₁₀ has shown a slight increase in concentrations of 10% at the end of April 2020 and PM_{2.5} has 40% increase during the initial relaxation period in April 2020 and these shows there is a significant background of traffic, dust resuspension, construction and industrial activities in the origin of particulate matter in a mega city [12] and the PM₁₀, PM_{2.5} concentrations of Chennai is in line with the results of the preceding report of air quality during the lockdown for a Megacity in India.

During the phase-wise relaxation of lockdown, the Chennai was categorized under the red zone and there was relaxation only for the transport of commodities in May 2020. Chennai received phase-wise relaxation on 1st June 2020. From this, the concentrations of PM₁₀ and PM_{2.5} have gradually increased and notably both the particulate matter concentrations were at their peak in the mid of June 2020. The peak concentrations of PM₁₀ and PM_{2.5} were observed to be 65 µg/m³ and 32 µg/m³, respectively.

The percentage variation of PM₁₀ and PM_{2.5} concentrations from complete lock down to the phase wise relaxation of lock down the peak concentration has increased by 38.46% and 53% respectively. Similar results were obtained for PM₁₀ and PM_{2.5} for all five regions throughout India and decrease in concentrations of particulate matter has witnessed the effectiveness of lock down [2]. Decrease in concentrations of these pollutants were noticed by ref [13] for Chennai Manali region at pre- and post-lock down period. During the month of August 2020 both the particulate matter has reached the peak level in phase wise relaxation of lock down and gradual decrease in concentrations was observed for two months, June 2020 and July 2020. It was interesting to note that at the post lock down particulate matter PM₁₀ concentrations has declined continuously. PM_{2.5} has also declined at the initial stage of post lock down and started increasing. Comparing the pre lock down and post lock down the concentrations of both the particulate matter were less in post lock down period. But during the entire study period both the particulate matters have not exceeded the NAAQS 2009 limit prescribed for air quality.

According to NAAQS 2009 the maximum permissible limit for the Nitrogen dioxide concentration in air was 80 µg/m³. Nitrogen Dioxide peak concentration of about 20 µg/m³ was observed at the end of Pre lockdown period and it exhibits similar concentrations at the post lock down period also. NO₂ concentrations were less beyond the permissible limit in Chennai [9, 14]. But the concentrations have significantly reduced within 4 days of complete lock down period to 50% when compared to the pre- and post-lock down period. The primary source of Nitrogen Dioxide is emission from vehicles, in particular from diesel fuel operated vehicles and manufacturing industries. During the complete lock down these activities are restricted and this may be the reason for the reduction of concentrations of NO₂. Based on the phase wise lockdown relaxation the fluctuation of concentrations was observed in June 2020 and it has almost reached the pre lock down level concentration in August 2020.

Sulphur Dioxide has shown more or less similar concentrations in the pre lock down and posts lock down period. During the complete lock down period sudden declination of 20% was observed and it was constant during the entire lockdown period and shows a slight variation while the relaxation for commodities transport. In Chennai city the SO₂ concentrations were less than the permissible limit which coincides with the results of the preceding studies [9, 15, 16].

3.2. Air Quality Index (AQI)

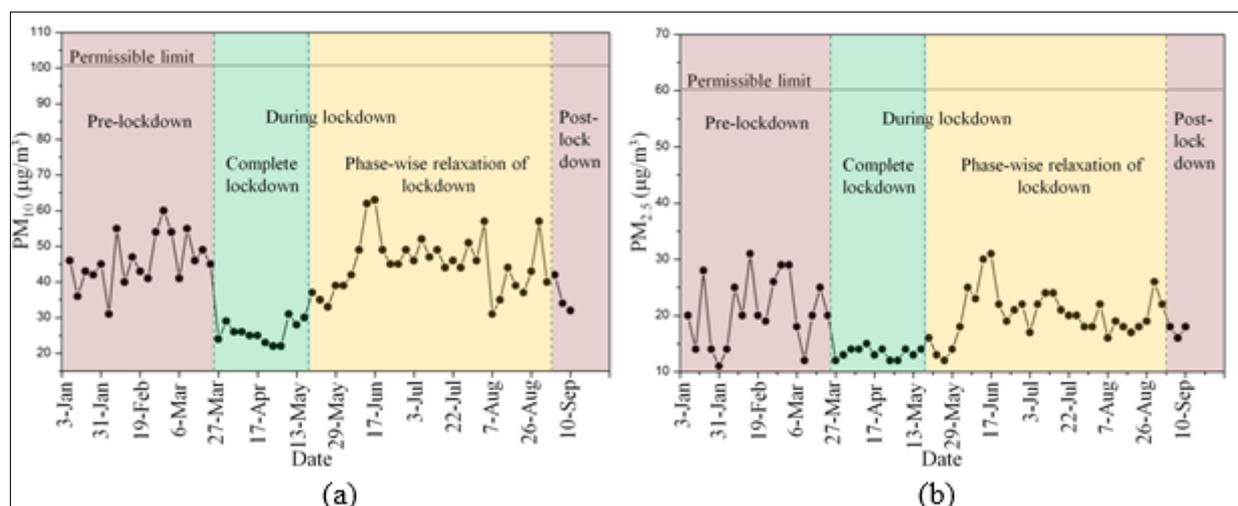
The air quality Index uses the pollutants such as Pb, PM₁₀, PM_{2.5}, CO, SO₂, NO₂, O₃ and NH₃. Out of these three major pollutants are used for AQI computation. The main particulate matter is either PM₁₀ or PM_{2.5}, and the other two air pollutants. The concentrations of these pollutants were converted to a scale of 1-300 for categorizing. The AQI is categorized into good for scale 0-50, Satisfactory for scale between 51-100, Moderate for scale between 101-200 and poor between the scale of 201-300 respectively. The AQI was good at the AQI scale in January 2020 and there were fluctuations in the

concentration in February and March 2020 at both these months the average scale of AQI was Satisfactory. When Lockdown was imposed there was sudden declination of AQI and in the entire lock down period the concentrations were below and in AQI scale represents good. In June 2020 there were fluctuations and peak value of concentrations was recorded and in AQI scale it has represented a satisfactory level. Interestingly in the post lock down period the concentration level of pollutants was on a good scale in AQI. During the lockdown period there was a reduction of 26% of the AQI concentrations of the pollutants. The results agree with the previous done for the mega city in India, all the 22 cities have shown 30% decrease of AQI for the past 4 years and south India especially has shown a decrease of 33% [2], which was nearer to our results obtained for Adyar region Chennai.

Understanding the Concentrations of PM₁₀ over the last 3 years

To have a better understanding of concentrations of particulate matter over 3 years in Chennai. PM₁₀ average 24h concentrations were obtained from the website of CPCB [17] and analyzed for concentrations. The PM₁₀ concentration was 35 $\mu\text{g}/\text{m}^3$ in March 2018 and same month in 2019 the concentrations were close to 95 $\mu\text{g}/\text{m}^3$ but in March 2020 the concentration has declined 45 $\mu\text{g}/\text{m}^3$ (Figure 2). The percentage decrease in the concentrations during preceding years in at same month was 52.63% between 2019 and 2020. It can be noticed that increase in the concentration of about 63.15% has occurred in the same month in 2018 and 2019. During the lockdown period the particulate matter concentration has 25 $\mu\text{g}/\text{m}^3$ which is below the concentrations for the past 3 years. Similar results of decrease in concentrations were attained by [12] for the Mega Indian city Delhi and it indicates that the lockdown and curfew may be an alternate solution for improving the air quality of Mega cities.

SO₂ concentrations levels have shown entirely different patterns of fluctuations for the past 3 years. In 2020 the concentrations were steady 8 $\mu\text{g}/\text{m}^3$ at pre lock down and post lockdown period. A declination in concentration was observed within the four days of lock down in March 2020 but during the complete down the concentration has declined about 12.5% in concentration levels. In the year 2019 the concentrations were 9 $\mu\text{g}/\text{m}^3$ for 6 months and except March 2019. In March 2019 a peak concentration of 10.2 $\mu\text{g}/\text{m}^3$ was observed, that was the higher concentration ever observed in the past 3 years and the next half year in 2019 the concentration levels have decreased whereas for the other 2 years (2018 and 2020) it was increased at the latter half for both the years.



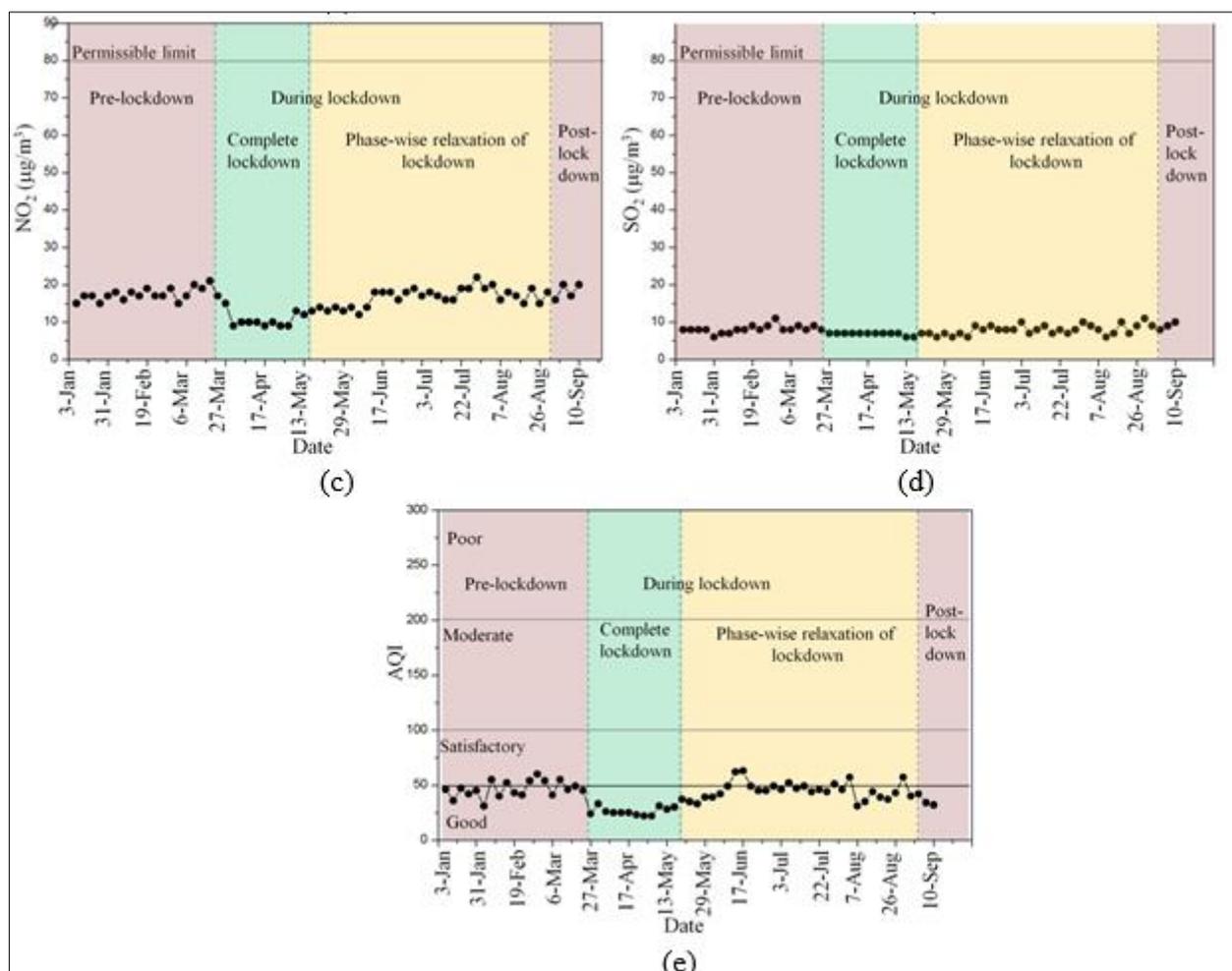


Figure 1. Air quality trend of Adyar, Chennai, pre-during-post lockdown. 24 h average concentrations of (a) PM₁₀, (b) PM_{2.5}, (c) NO₂, (d) SO₂, and (e) AQI. The levels

Table 1. Status of daily air quality parameters pre-, during and post-lockdown

Date		PM ₁₀	PM _{2.5}	SO ₂	NO ₂	AQI
3/1/2020	1	46	20	8	15	46
22/1/2020	2	36	14	8	17	36
24/1/2020	3	43	28	8	17	47
29/1/2020	4	42	14	8	15	42
31/1/2020	5	45	11	6	17	45
5/2/2020	6	31	14	7	18	31
7/2/2020	7	55	25	7	16	55
12/2/2020	8	40	20	8	18	40
14/2/2020	9	47	31	8	17	52
19/2/2020	10	43	20	9	19	43
21/2/2020	11	41	19	8	17	41
26/2/2020	12	54	26	9	17	54
28/2/2020	13	60	29	11	19	60
4/3/2020	14	54	29	8	15	54
6/3/2020	15	41	18	8	17	41
11/3/2020	16	55	12	9	20	55
13/3/2020	17	46	20	8	19	46



18/3/2020	18	49	25	9	21	49
20/3/2020	19	45	20	8	17	45
27/3/2020	20	24	12	7	15	24
1/4/2020	21	29	13	7	9	33
3/4/2020	22	26	14	7	10	26
8/4/2020	23	26	14	7	10	25
15/4/2020	24	25	15	7	10	25
17/4/2020	25	25	13	7	9	25
22/4/2020	26	23	14	7	10	23
24/4/2020	27	22	12	7	9	22
29/4/2020	28	22	12	7	9	22
8/5/2020	29	31	14	7	13	31
13/5/2020	30	28	13	6	12	28
15/5/2020	31	30	14	6	13	30
20/5/2020	32	37	16	7	14	37
22/5/2020	33	35	13	7	13	35
27/5/2020	34	33	12	6	14	33
29/5/2020	35	39	14	7	13	39
3/6/2020	36	39	18	6	14	39
5/6/2020	37	42	25	7	12	42
10/6/2020	38	49	23	6	14	49
12/6/2020	39	62	30	9	18	62
17/6/2020	40	63	31	8	18	63
19/6/2020	41	49	22	9	18	49
24/6/2020	42	45	19	8	16	45
26/6/2020	43	45	21	8	18	45
1/7/2020	44	49	22	8	19	49
3/7/2020	45	46	17	10	17	46
8/7/2020	46	52	22	7	18	52
10/7/2020	47	47	24	8	17	47
15/7/2020	48	49	24	9	16	49
17/7/2020	49	44	21	7	16	44
22/7/2020	50	46	20	8	19	46
24/7/2020	51	44	20	7	19	44
29/7/2020	52	51	18	8	22	51
31/7/2020	53	46	18	10	19	46
5/8/2020	54	57	22	9	20	57
7/8/2020	55	31	16	8	16	31
12/8/2020	56	35	19	6	18	35
14/8/2020	57	44	18	7	17	44
19/8/2020	58	39	17	10	15	39
21/8/2020	59	37	18	7	19	37
26/8/2020	60	43	19	9	15	43
28/8/2020	61	57	26	11	18	57
2/9/2020	62	40	22	9	16	40

4/9/2020	63	42	18	8	20	42
8/9/2020	64	34	16	9	17	34
10/9/2020	65	32	18	10	20	32

Notes: PM_{2.5} - 0-15 - dark green, 16-30 - mild green, 31-60 - orange. PM₁₀ - 0-30 - dark green, 31-50 - mild green, above 51 - orange. SO₂ - 0-7 - dark green, 8-40 - mild green. NO₂ - 0-15 - dark green, 16-40 - mild green. AQI - 0-30 - dark green, 31-20 - mild green, 51-100 - orange.

The primary source of nitrogen dioxide is emission from vehicles, in particular from diesel fuel operated vehicles and manufacturing industries. During the complete lock down these activities are restricted and this may be a reason for the reduction of concentrations of NO₂. Based on the phase wise lockdown relaxation the fluctuation of concentrations was observed in June 2020 and it has almost reached the pre lock down level concentration in August 2020.

4. Conclusions

The present study gives insight on the effect of the implementation of lockdown due to COVID-19 pandemic on the air quality of the megacity Chennai, India. Adyar region in Chennai is one of the most populated areas surrounded by the areas that are classified as an industrial areas. The levels of pollutants such as PM₁₀, PM_{2.5}, sulphur dioxide, and nitrous oxide for the period pre-during and post lock down were correlated. The results indicated that the concentrations of particulate matter decreased up to 80% and the levels of sulphur dioxide and nitrous oxide decreased up to 40% within the first week of lock down. Further the average levels of PM₁₀, sulphur dioxide, and nitrous oxide were compared with the previous years and it was noted that the lockdown reduced their levels significantly. From the scientific insights given in this study, it is suggested that reduction in pollution levels can be achieved by the implementation of short term (less than a week) lockdown which could effectively refresh the environment.

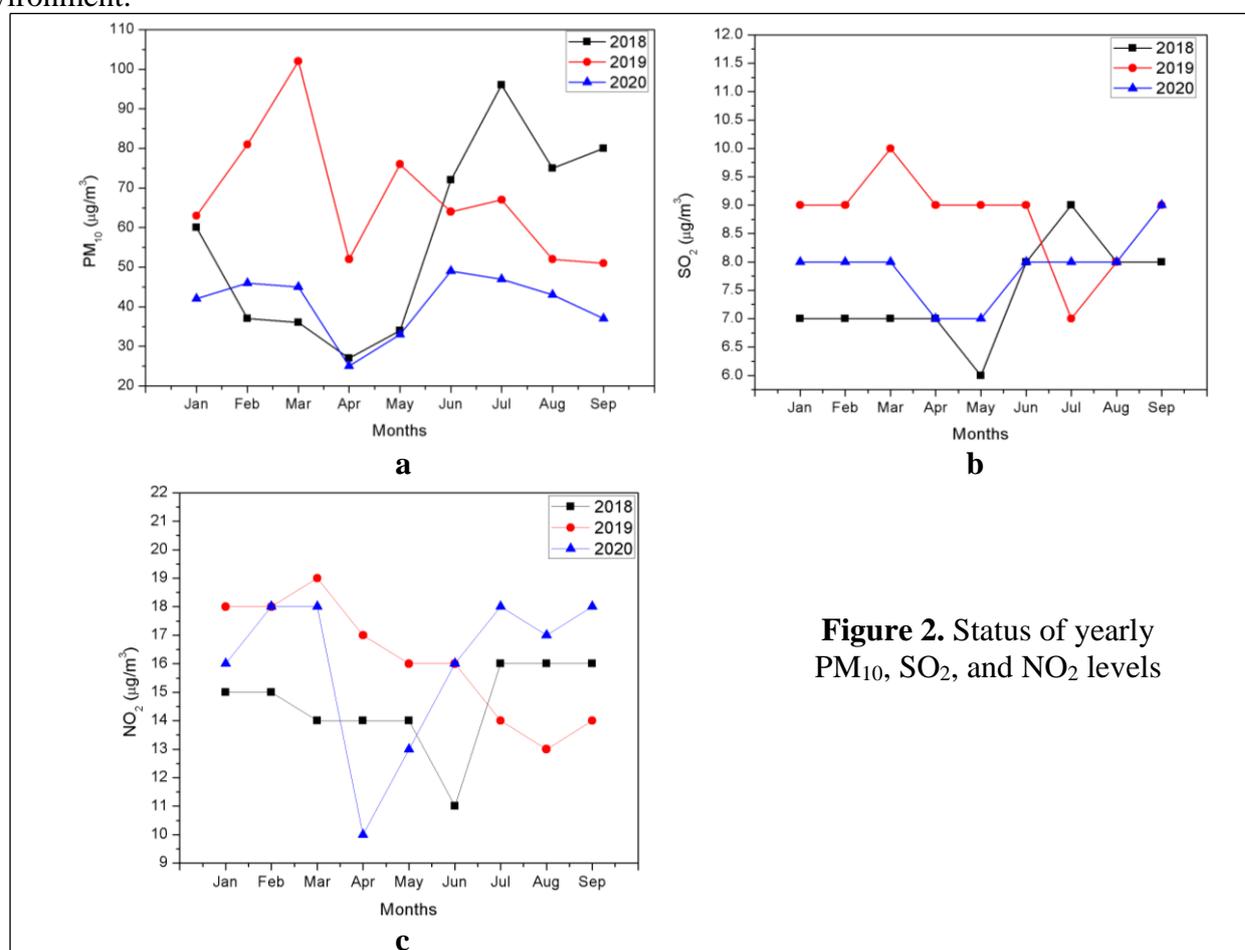


Figure 2. Status of yearly PM₁₀, SO₂, and NO₂ levels



Acknowledgments. The authors are thankful to Tamil Nadu Dr.J. Jayalalithaa Fisheries University for encouragement and support towards the research.

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Manuscript received: 17.08.2021